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the house ceased in 1886, but the incorporated name of the firm continues. Ill health detained him from business alliances for awhile, but he was identified for a short time with a manufacturing interest in this city. In 1888 his health again failed and his trips to warmer climes did not bring relief. Latterly his home has been with his son at New Rochelle, New York, till his death, June 28, 1892.

As a writer Mr. Fuller was clear, concise, and convincing. In science he was quite an adept, his fondness for chemistry leading him into many investigations. In addition, he cultivated the use of the microscope, which opened a field for work and leisure that he loved and prosecuted ardently. His microscopical work was recognized by societies at home and abroad, and brought him the honorary membership and pleasures of associations. Taking an active part in pharmacy, he was at one time the president of the Chicago College of Pharmacy. His wife, son (Henry F.), and a daughter survive him, the daughter being the wife of H. R. Saunders, the American vice-consul at Nassau, Bahamas. His only surviving brother is Chief Justice Fuller, of the United States Supreme Court. Mr. Fuller was one of the purest and noblest of men, both in business and social life, and no pen tribute can do justice to the work or worth of his manhood life.

JOSEPH ZENTMAYER.

In a preceding volume of the Proceedings some effort was made to give a general idea of the history of the development of the construction of the microscope, and extended articles have been published on C. A. Spencer and Robert B. Tolles, who may be considered as the pioneers in the manufacture of American microscopes. The Proceedings have not hitherto contained any notice of a man who also contributed his full share in this work, viz., Joseph Zentmayer. It does not appear that he was ever a member of our Society, though he was proposed for membership; but the active part he took in developing a particular form of the microscope justifies the publication here of the following facts, taken from a more extended notice which appeared in the *Journal of the Franklin Institute*, December, 1888.

Joseph Zentmayer, optician, whose name was known all over the world, was born in Mannheim, Baden, in South Germany, in 1826.

He received a good education, and learned his trade as an instrument-maker. At the termination of his apprenticeship, and after having made his "masterpiece," as is the custom among German mechanics, he traveled throughout Germany, working in the best establishments and improving himself in the knowledge and use of scientific instruments. He was an ardent republican, and his natural love of liberty led him to take an active part in the agitation that had as its object the establishment of republican institutions in Germany.

He came to America in 1848, in the twenty-fourth year of his age, hoping to find a free scope for his notions of freedom in the Western Republic. Between 1848 and 1853 he worked for the best instrument-makers in Baltimore, Washington, and in Philadelphia. In 1853 he began to make mathematical instruments in Philadelphia, at Eighth and Chestnut streets, with but one single lathe. The high character of his work and the boldness of his conceptions attracted the attention of the leading scientific men. Among these, the late Dr. Paul B. Goddard was particularly drawn to him, and it was Dr. Goddard who persuaded him to make the first of his large compound microscopes. This early effort was so successful that the Academy of Natural Sciences and many of the leading physicians who required such instruments purchased those of his make and discarded the heavy and yet unstable instruments of European manufacture. Once fully embarked in this enterprise it seemed to absorb his whole attention, and many were the improvements that followed each other in rapid succession, not only in the stand of the microscope, but in its objectives. At the present time there is not a maker of microscopes in the world who does not use some of the important inventions of this Philadelphia mechanician. During the war for the Union he furnished most of the microscopes used in the Government hospitals, and he received the highest commendation from all the officers and other authorities for his work.

In 1865 he invented his photographic lens. The story of his invention of this photographic objective is very interesting. At the time when the Harrison globe lens was attracting attention Prof. Coleman Sellers was requested to write a paper for the *American Journal of Science and Arts* on the nature and advantages of the globe lens for the photographic camera. After this was published its writer consulted Mr. Zentmayer about the combination, and he said that it was quite possible to make a lens of two simple

uncorrected concavo-convex or meniscus glasses, made thin and of proper curves, and that such a lens would be chemically correct as to focus, and would also copy a drawing with the marginal lines straight—that is, without any bending of the lines either out or in. He was urged to make a lens of this kind, and finally he did so, sending it to Professor Sellers to test. That first lens, made as he had proposed, was perfect in its definition, and had all the good qualities he had promised. Most lenses for this kind of work have been the result of a long series of experiments ending in the form adopted. In this case a lens constructed upon a theory proved the correctness of that theory in a most remarkable manner. The Zentmayer lens, which in working is as rapid, if not more so, than other globe lenses in the market, was more simple and filled a want, inasmuch as his system enabled him to make a series of lenses, the front of one lens being used as the back one of another through a series of sizes from the longest focus wanted to the shortest; a set of these lenses, combined as required, meeting all cases that could occur, both as to size of plate and proportion of reduction. Mr. Zentmayer's patent for these lenses was not granted at once, but he was obliged to contest his claim before a master, in which examination his claim in regard to priority was fully sustained.

So radically original was the invention embodied in this lens that the descriptions of it were at first regarded by the practical opticians of Europe as incredible and as American exaggerations, and these ideas led to quite an animated controversy, which may be found in the *Journal of the Franklin Institute*, 1867, vol. 83, p. 349; also 1868, vol. 85, p. 153, and more fully in the *Philadelphia Photographer*, 1867, vol. 4, pp. 177, 251, 253, 344; also 1868, vol. 5, pp. 79, 109.

After the system of screw-threads known as the "United States" or the "Franklin Institute standard system of screw-threads" was introduced and makers called for instruments to measure the amount of reduction or the width of the flat top and bottom of the threads, a set of thin steel plates ground to an angle of 60° was sent to Mr. Zentmayer to have him grind the apex of each to the proper amount, the width of each being given to him in decimals of an inch to the fourth point. In topping these off he measured the flat by means of a stage and eye-piece micrometer. The correctness of his work was then verified by a member of this committee, who, taking the finished pieces, measured them on his own microscope in the same manner, setting down the dimensions as found, and afterwards com-

paring them with what was required, with the result of finding them correct to the fourth place of decimals in each case. This was, in the first place, one of the earliest instances in which the microscope was used in such a mechanical process, and a remarkable example of the facility with which good instruments can be used in such work of precision. The standard gauges, made since by the Brown & Sharpe Manufacturing Company, have all been adjusted to the standard pieces prepared by Mr. Zentmayer.

The wonderful comparator, designed by Professor Rogers, of Boston, and made and used by the Pratt & Whitney Company, of Hartford, Conn., is furnished with microscopes made by Mr. Zentmayer, who took great pains to perfect the instruments to be applied to this system of comparing measurements. In all cases where work of great nicety has been required, those who knew Mr. Zentmayer's skill were in the habit of seeking his aid, even in matters not pertaining to optics. The freedom from petty jealousy that marked his character was pleasing to his many friends. No one ever heard him say a harsh word about rivals in trade, even when in the contests, called by some sharpness in trade, he might justly blame some for having acted unfairly. Those who have been for years in the habit of visiting him in his shop know how kind he always was and how patiently he listened to what they had to say, giving freely from his great store of knowledge, showing his methods and even supplying to those who wished to make any piece of apparatus themselves such parts as he could find suited to their purpose.

Mr. Zentmayer's office in Walnut street, where he had his lathe close to his counter and near to the cases containing his instruments, was the meeting place of all the scientists of the day. There, at all times, while he was working, professors and physicians and mechanical engineers would meet and discuss problems in optics or in mechanism, all of these men learning to love the good man who was so simple-minded and so honest in his dealings. Many times young men, coming to purchase their first microscope, found the great optician advising the purchase of a good working instrument cheaper than the one they had come to buy, but well fitted to do what would be required of it. No instrument would leave his hands without being personally inspected by him, after he had advanced to the condition of employing workmen to do what at first he did with his own hands. All those who knew Mr. Zentmayer felt the influence of his honest, straightforward seeking after truth. It was always a source of pride to him that among the many thousand in-

struments which he constructed, none ever came back for repair after years of hard usage, except in the case of severe accident, such as would come from a fall, or the like. No amount of work ever did them harm.

The great triumph of his microscope-making was the perfection of the stand, known as that of 1876, which elicited so much favorable comment during our Centennial Exhibition. The invention and practical application of his swinging substage, that enabled him to rotate the illuminating apparatus completely around the object without disturbing its focus, were marked examples of his talent. Others may claim to have made something similar, but none had ever made it so perfect as to be substantially new to all who used it. Now no good microscope is made without this important arrangement of the stand. The binocular microscope, under his hands, became more useful than ever before. It was not until he had perfected this form that he was willing to sell a binocular instrument. He knew the good that was to be obtained by means of the binocular principle, but he was unwilling to make one for sale until at last he had surmounted all the objections he saw in the system, and had made so perfect an instrument that he did not fear to attach his name and reputation to it.

In the construction of his simple form of sliding stage others may claim the prior invention of the principle in a crude form, but it is very certain that to Mr. Zentmayer, and to him alone, is due the credit of making this simple device as perfect as the most costly compound stage, so far as comfort of working and certainty of motion is concerned. To suggest is one thing, but to perfect into an efficient instrument is perhaps the most important after all.

Mr. Zentmayer was not willing to push himself forward, but when he at last was persuaded to lecture on optics at the Franklin Institute his lecture proved to be as well worthy of the man as all his mechanical work. It stands to-day as an important addition to the literature of optics.

Mr. Zen mayer's musical education, as well as his artistic, made him an appreciative critic, and among his countrymen his poetry is valued. He was so loving and so kind, so winning in his ways, that all who came in contact with him were attracted toward him, and when his last illness came, warning them that the mind they had valued so highly was losing its great strength, they mourned his death long before the actual dissolution of his body.

The illness that at last resulted in the death of Mr. Zentmayer

came on very slowly, and fortunately only after he had instructed his sons in the processes that had made his work so celebrated. Those sons have had charge for a number of years of the construction of the instruments which have given such great satisfaction to all who have used them. To members of this committee of the Franklin Institute the father confided his system of education of his children, and to them he explained how thoroughly he had informed them of the minutiae of his operations that they might worthily carry on a business of which he was so proud. Mr. Zentmayer would never do any work slightly. What was to be done must be done well, his constant effort being to improve his methods as well as improve the construction of his instruments.

As a writer Mr. Zentmayer was not prolific, preferring to express his ideas verbally to his friends rather than to put them on paper for publication. We find, however, the following articles which were his work in the *Journal of the Franklin Institute* :

On a Mechanical Finger for Use in Mounting Diatoms under the Microscope, 1870, vol. 89, p. 334.

On an Erecting Prism for Use in the Microscope, 1872, vol. 93, p. 375 ; A Lecture on Lenses, 1876, vol. 101, pp. 336 and 421.

On Improvements in Microscopes, 1877, vol. 104, p. 49.

Also in the *Philadelphia Photographer*, 1867, vol. 4, p. 251, we find an article entitled "Refraction without Dispersion, and some Reflections," in which he takes a hand in the controversy about his photographic lens with marked ability.

DR. J. GIBBONS HUNT.

Among the intimate associates of Joseph Zentmayer in microscopy was Dr. J. Gibbons Hunt, who died at Lansdowne, Pa., April 29th, 1893, aged 67. Like Zentmayer, Dr. Hunt was not prolific in publication, although he contributed a number of short articles to the Cincinnati *Medical News* and some minor periodicals. As a manipulator of the microscope and preparer of objects he was unsurpassed, but he looked on this skill as only the means to an end—a knowledge of the objects themselves. Having made himself familiar with animal histology, he very early turned his attention to the anatomy of plants, of which he acquired an intimate knowl-